Notes and Comments

Ecogeographical Patterning and Stature Prediction in Fossil Hominids: Comment on M.R. Feldesman and R.L. Fountain, *American Journal of Physical Anthropology* (1996)100:207–224.

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Human body proportions vary with climatological and/or geographic parameters, presumably due to long-term climatic selection (Allen, 1877; Schreider, 1950; Roberts, 1978; Crognier, 1981; Trinkaus, 1981). In a recent paper, however, Feldesman and Fountain (1996) have argued that "racial" affinity (or more importantly, body proportions) need not be taken into consideration when estimating stature in fossil hominids. Rather than use population-specific regression equations and/or ratios to predict stature, these authors argue that a "generic" (i.e., average global) ratio provides the most accurate predictor of stature when "racial" affinity is unknown (as is the case for fossil hominids). This is, in some regards, in direct contradiction to an argument made by one of us (Ruff, 1991, 1993, 1994) that stature estimations for fossil hominids should be based on equations derived from modern populations with similar body proportions.

Feldesman and Fountain give two main reasons for their dissent from this position. The first is that one "cannot use appropriately proportioned reference samples to estimate stature in fossil hominids without knowing the proportions of those hominids. To do so requires that at some general level we know stature, the very quantity we are interested in estimating" (Feldesman and Fountain, 1996, p. 209).

This statement is simply not correct. Body proportions can be examined in ways other than the stature-dependent femur/stature ratio. For example, Trinkaus (1981) has shown that crural indices (reflective of body linearity) vary with climate, yet one need not know stature to compute them. Likewise, femoral head size relative to femoral length also provides an indication of overall body linearity. It, too, varies with climate and geography (Ruff, 1994; Holliday, 1995), and can be computed without an a priori knowledge of stature. Finally, bi-iliac breadth relative to femoral length shows strong ecogeographic variation and is another way to assess body proportions independent of stature reconstruction (Ruff, 1994).

An even more direct way to assess relative limb length and its contribution to stature in skeletal remains is to compare long bone lengths to trunk height, the other major component of stature. It has been demonstrated (Holliday and Trinkaus, 1991; Holliday, 1995, 1997) that skeletal limb length/trunk height ratios vary significantly and systematically between broad geographical areas. Figure 1 is a scatter plot for recent humans of femoral bicondylar length on skeletal trunk height (the summed dorsal body heights of T1-L5 and sacral ventral length; Franciscus and Holliday, 1992). It shows clear proportional differences between recent Sub-Saharan Africans (the triangles; $n = 43$) and recent Europeans (the squares; $n = 123$), with the Africans possessing significantly longer femora relative to trunk height. Since both trunk height and femoral length are components of stature, a Sub-Saharan African-based regression (or ratio) for predicting stature from femur

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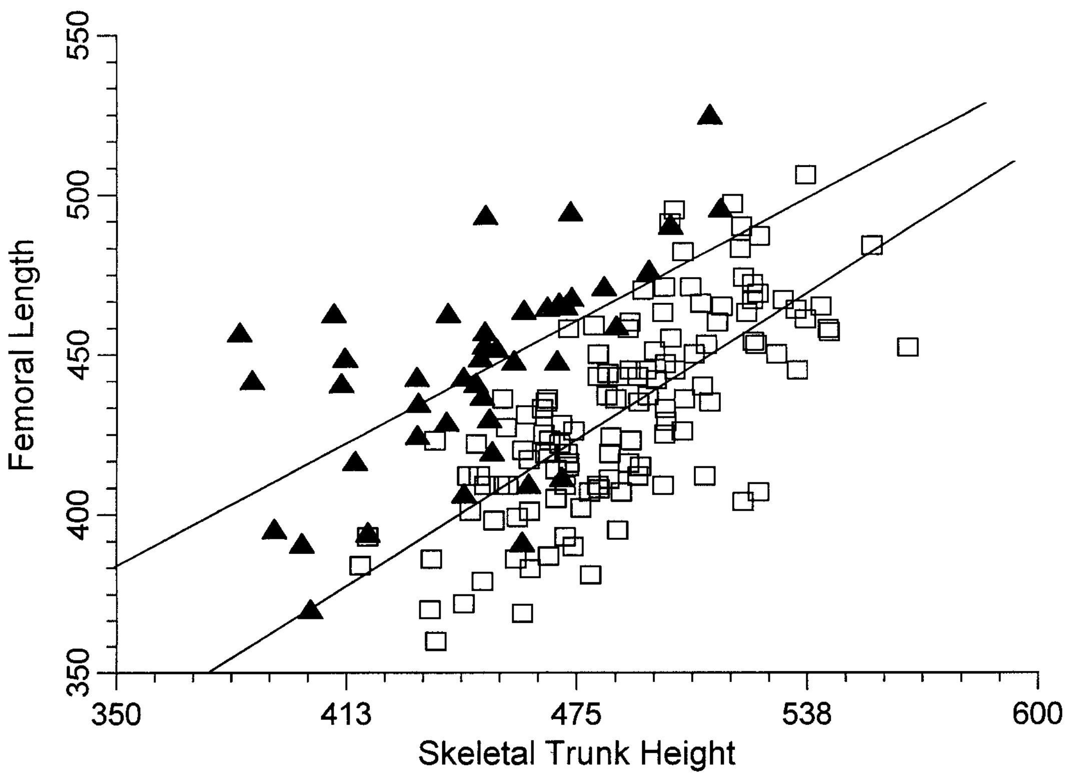

Fig. 1. Femoral bicondylar length regressed on skeletal trunk height. Triangles = Sub-Saharan Africans; squares = Europeans. Least-squares regression lines for each group are also plotted. European slope = 0.761; Y-intercept = 60.735; African slope = 0.606; Y-intercept = 172.610. Slopes are not significantly different, while ANCOVA reveals that the elevations of the two lines are significantly different ($P < 0.0001$).

length will systematically underestimate the stature of Europeans, while a European-based regression (or ratio) will systematically overestimate the stature of Sub-Saharan Africans. This is despite the presence of some overlap between the two groups. With some exceptions (discussed below) this ecogeographic patterning holds for Pleistocene humans, as well (Holliday, 1995, 1997).

The second reason Feldesman and Fountain (1996) give for preferring a "generic" over a population-specific means of stature prediction is that their "racial" groups have low within-group coherence. That is, their ability to assign recent samples to the proper "racial" category based on relative limb length is limited. However, this finding may be due, in part, to problems in their sample composition, particularly within their "Black" group. This group is comprised almost entirely of U.S. Blacks (n = 9) and African Pygmies (n = 4), neither of which is representative of most tropical populations in terms of relative limb length (Ruff and Walker, 1993; Ruff, 1994; Holliday, 1995; Shea and Bailey, 1996). In the case of African Pygmies, this is confirmed by Feldesman and Fountain's own data (their Table 1): the average femur/stature ratio of their four Pygmy samples (26.3 ± 0.52 SD) is significantly ($P < .0004$) lower than the average of their other 11 "Black" samples (27.43 ± 0.37 SD). Without the Pygmies, all but two of the 11 "Black" sample means are outside the total range represented in the "Asian" and "White" samples (n = 40), and the two "Black" samples that do overlap significantly are African-American.

In addition to these problems with the "Black" group, the "Asian" group is extremely heterogeneous, geographically and

climatically, including population samples as diverse as subcontinental Indians and Inuit. Hence it is not surprising that low concordance was found within these "racial" groups. This also serves to emphasize that it is not "race" in a typological sense, but rather clinal patterns in body shape that are important in this context. While we cannot easily assign "race" to fossil specimens, we can examine their body shape, which is really the parameter of interest.

Finally, Feldesman and Fountain's repeatedly stated inference (1996, pp. 220, 221, 222) that use of a "generic" formula over a "race-specific" formula for estimating stature will only result in a very small loss in accuracy of some 0.6–1.2 cm is misleading if taken at face value. In fact, use of different formulae can result in very different stature estimates, as illustrated in Table 1 for the early *Homo* KNM-WT 15000. Feldesman and Fountain (1996, pp. 208, 210) remark that the juvenile stature estimates for this specimen, i.e., estimates of his stature at death (about 11–12 years of age) are "virtually identical" using different methods and modern reference samples. In fact, estimates have varied from 157.4 cm (Feldesman, 1992) to 161.8 (Feldesman et al., 1990), not an insignificant range. However, the range of variation in his estimated stature as an adult using different techniques is far greater (Table 1). By every measure, KNM-WT 15000 was tropically proportioned, even "hyper-tropically" proportioned (Ruff and Walker, 1993; Ruff, 1993, 1994). Thus, it is extremely likely that modern African reference samples will produce much more accurate stature estimates for this specimen than worldwide "generic" samples. This was the "epistemological" basis for Ruff's (1993) statement that these estimates were the "most reasonable" (Feldesman and Fountain, 1996, p. 208). The likely error involved in using a worldwide reference sample for this specimen is on the order of 10 cm (Table 1). Thus, contra Feldesman and Fountain, the penalty for using the "generic" ratio can be substantial.

Feldesman and Fountain rightly caution against application of "race"-specific stature estimation formulae when little or nothing is known about body proportions of the

TABLE 1. Stature estimates for KNM-WT 15000 as an adult using different techniques

Predictor variable[1]	Technique	Stature estimate (cm)[2]
Maximum femoral length (52.1 cm)	Feldesman and Fountain's (1996) "generic" ratio	194.8
Maximum femoral length (52.1 cm)	Feldesman and Fountain's (1996) "Black" ratio	192.0
Bicondylar femoral length (51.7 cm)	Feldesman and Lundy's (1988) South African Black regression formula (males)	181.4
Bicondylar tibial length (45.8 cm)	Allbrook's (1961) Nilohamite regression formula	184.0

[1]Lengths are adult averages assuming an age at death of 11 or 12 years (see Ruff and Walker, 1993).
[2]The best estimate of KNM-WT 15000's stature as an adult, taking into account all available skeletal material and modern reference samples, is about 185 cm (Ruff and Walker, 1993).

skeletal specimens. However, in many cases body proportions can be assessed, as described above, either for the specimens themselves or for closely related specimens. In other cases a reasonable inference regarding body proportions can be drawn if uniformitarian principles (both empirical and theoretical) are applied. For example, in every case where it can be directly assessed, from *Homo erectus* through modern *H. sapiens*, the body proportions of tropical populations or individuals are different from those of higher latitude populations/individuals (with the exception of Polynesians, a special case as discussed in Ruff, 1994). Therefore, it is most reasonable to assume that tropical populations in general will exhibit these proportions. This was the rationale behind Ruff and Walker's (1993) use of African-based stature formulae for several East African early *Homo* specimens, and latitudinally based body mass estimates for the same specimens, estimates also employed by McHenry (1994).

This does not mean that climatically or geographically based formulae should be applied blindly. For example, the earliest modern Europeans, despite inhabiting glacial Europe, tended nonetheless to be characterized by a more tropically adapted body form (Trinkaus, 1981; Ruff, 1994; Holliday, 1995, 1997), an observation that supports the hypothesis of significant gene flow and/or

migration from Africa at this time (Stringer and Andrews, 1988; Smith and Trinkaus, 1991; Bräuer, 1992; Mountain et al., 1993). It is obviously important to consider all factors, including historical factors, when assessing the appropriateness of a particular modern reference sample for estimating body size from skeletal remains. However, when a reasonable inference regarding body proportions can be made, use of a modern sample with similar proportions will give more accurate results than use of a "generic" or "averaged-proportioned" sample.

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